EVALUATION OF FROZEN BEEF PATTIES CONTAINING SOY PROTEIN

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EVALUATION OF FROZEN BEEF PATTIES CONTAINING SOY PROTEIN

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BEEF	FAT	BEEF PATTIES	ACCEPTABILITY	SOY ADDITIVES
TESTS	ASH	ADDITIVES	CONDIMENTS	EVALUATION
COLOR	SOY	STORAGE	SOY PROTEIN	FROZEN FOODS
MEAT	ACIDS	MOISTURE	FLAVOR	FROZEN BEEF
	FOOD	PROTEIN	APPEARANCE	TEXTURE

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Four samples of textured soy protein (TSP) and two of granular soy protein concentrate (SPC) were incorporated into ground beef at levels of 20 and 30% in accord with Food Nutrition Service Notice 219. Patties prepared therefrom together with an all-beef control were frozen and examined at 0, 3, 6, 9 and 12 months. Examination included proximate analysis; ph, peroxide and thiobarbituric acid values; and, after standardized cooking, evaluation by 3 types

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of panels for flavor, tenderness, appearance, aroma, juiciness, and over-all acceptability. Soy additives did not promote oxidative or sensory changes during 12 months frozen storage. Patties with 20% TSP rated slightly lower in flavor than the control but in general this difference was not significant ($P > 0.05$). No trend was noted for appearance, aroma, juiciness and over-all acceptability, while tenderness was significantly improved. With 30% TSP the frequency of significantly lower flavor ratings increased. The trend toward reduced ratings for appearance, aroma and over-all acceptability was mainly caused by one of the 4 samples. Tenderness ratings continued to increase. At 20% SPC's were inferior to the control due primarily to significant flavor differences and to generally lower ratings in appearance and over-all acceptability. Differences were magnified with 30% SPC. Use of condiments tended to obliterate differences.

FOREWORD

For more than a decade increasing attention has been given to the use of soy bean products to supplement, extend or replace the native protein of a variety of food items, to modify food structure, and in several cases to simulate specific items. From knowledge of the expanding technical and trade literatures dealing with applications of soy bean products in the food industry, from contacts with a number of processors of soy bean products, from information forthcoming from educational institutions active in research and development of soy bean products and from the Agricultural Research Service and the Food and Nutrition Service of the US Department of Agriculture (USDA), it was apparent that the Armed Forces should be knowledgeable of the positive and negative features of such soy bean products. From the above sources it became evident that the most immediate major use of soy bean derivatives is as an extender for meat, primarily ground beef; such an application has been underway for several years in the School Lunch Program. During 1971 the Armed Forces procured for troop issue a total of 19 $(10)^6$ kg of ground beef, 11 $(10)^6$ kg as preformed patties, and 9 $(10)^6$ kg as bulk ground beef which is used for such items as chili, meat loaf, meat balls and the formulated items. Advice from USDA indicated that more problems were likely to be encountered with the use of structured soy bean flour or concentrate in patties than in bulk ground beef. As analyzed from available information, two questions of major significance to military applications remained unanswered. First, would commercially prepared ground beef patties extended with structured soy bean flour or concentrate withstand nine months of frozen storage? Second, what is the acceptability of such patties after frozen storage? This investigation was undertaken to provide information on these issues.

The study was conducted by the USDA Agricultural Research Service, Marketing Research Institute, Beltsville, Maryland under Project Order AMXRED 72-192. The study was financed with O & MA funds under DOD Production Engineering in support of Stock Fund Food and Food Service Items. Dr. Anthony W. Kotula served as Principal Investigator with Mr. G. G. Twigg and Dr. E. P. Young as collaborators. Mr. E. James Koch provided guidance and assistance with the statistical analysis of the data. Archer Daniels Midland Co., Cargill Inc., Pfizer Inc., Swift and Co., and Central Soy Co., Inc. provided soy protein samples and technical assistance in patty fabrication. Dr. Maxwell C. Brockmann and Mr. John Secrist served as Project Officer and Alternate Project Officer, respectively, for the US Army Natick Development Center.

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INTRODUCTION

The earliest recorded use of soybeans dates back to 2800 B.C. in China. Soybeans have had limited use in the United States even though this country leads the world in soybean production (Bentley, 1967). Since its introduction into this country around the turn of the century, the soybean has steadily progressed to become the United States' second ranking cash crop and major dollar earner in export marketing (Rakosky, 1967). Most of the foreign market lies in the Orient where the soybean is well-established protein source served in a variety of food dishes including: shoyu (soy sauce), miso, sufu, and tempeh (Hesseltine, 1967; Wolf, 1970). Within the past 35 years, soybeans, high in polyunsaturated oil, have become our key source of edible oils, used primarily in shortening, margarine, and salad oils.

Owing to its high protein content, low cost and good nutritional quality, much of the soy protein produced in this country is used for animal feed in the form of soybean meal. In today's food industry, soy protein is principally utilized for its functional properties. However, a number of companies are presently developing foods in which soy proteins are the predominant source of protein. More recently, the rising costs of animal proteins and the availability of more varied and refined soy protein products have engendered a pronounced interest in the use of soy proteins as possible extenders for animal and dairy proteins. The United States Department of Agriculture allows the use of soy protein as an extender for ground beef and has encouraged its use in School Lunch Programs.

OBJECTIVE

This study was undertaken to describe the chemical and organoleptic changes during frozen storage of beef patties containing soy proteins. Through standard procedures of proximate analysis, chemical tests for rancidity, and taste panel evaluations, an insight was sought into the acceptability and behavior during frozen storage of beef patties prepared under commercial conditions with specific additions of structured soy protein. Such information is needed for developing a position with respect to the use by the Armed Forces of soybean products as meat extenders.

PROCEDURE

Patty Fabrication

Twelve lots of 85 g beef patties, six containing 20% and the remaining six containing 30% hydrated soy protein, were prepared at a commercial meat processing plant from the following products:

Textured Vegetable Protein
Archer Daniels Midland - Fortified TVP[1/]
Cargill - Textratein
Pfizer - Chiplet - 200
Swift - Texgran

Concentrates
Central Soya - Promosoy - SL
Swift - SFP

All soy proteins were dehydrated, vitamin enriched, and contained no flavor additives. However, differences in physical appearance did exist. (See Photos 1-6). Approximately 228.6 kg of beef patties containing hydrated soy protein were formulated for each lot according to the recommendations described in the USDA Food and Nutrition Service Notice 219: for the School Lunch Program (1972).

As a control, a 453.6 kg lot of "all beef" (80% beef/20% fat) patties was prepared. Meat for producing all lots of beef patties was obtained from U.S.D.A. Good Grade triangle beef (chuck, brisket, plate) in accordance with Military Standard 105D. In order to maintain fat content at about 20.5% in all patties, the beef for formulating patties at about the 20% level of hydrated soy protein contained around 25.5% fat; whereas, meat used for fabricating patties having 30% hydrated soy protein, initially contained about 29.5% fat. The meat used for the "all beef" patties contained about 20.5% fat.

The specified quantity of meat for each lot, as listed above, was ground through a 2.54 cm plate. The Hobart[1/] fat tester and a chemical method of Bittenbender (1970) were both used for determination of fat on samples taken at random from each lot. Adjustments were made on the percentage of fat in each lot, by correcting with 50/50 trim, or 80/20 triangle, and fat determinations were again made to ensure proper fat content. Meat for all lots was stored in meat trucks and placed in coolers to maintain meat temperature at -2 to 0°C.

Hydration

Soy proteins were hydrated under the direction of the manufacturer's representative, except for the Cargill product. Tap water (16°C.) was used

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1/ Mention of product names throughout this report does not imply endorsement by the Government.

to hydrate all products. All soy proteins were hydrated a minimum of 10 minutes to ensure complete hydration. Swift's products were hydrated in meat trucks for about 15 minutes. Appropriate quantities of coarse ground meat and hydrated soy protein were alternately added to a mixer, and blended for approximately three minutes. Pfizer's representative hydrated the soy protein using the same procedures. Archer Daniels Midland and Central Soya representatives chose to hydrate their products in the mixer. Proper amounts of protein and water were added. After a ten-minute hydration period, the meat was added, and the ingredients mixed for five minutes. Since Cargill had no representative present, their product was prepared following the procedure of Archer Daniels Midland and Central Soya.

Packaging and Storage

Each lot of the meat-hydrated soy protein mixture was ground through a double screw 3.2 mm plate grinder, then, carried on a conveyor to a patty machine which subsequently formed the mix into 85-g patties.

The patties were packed into 47.6 cm x 33 cm x 15.2 cm boxes which met Military requirements for overseas shipment (Federal Specifications: PPP -B-636c, and L-P-378c; and Military Standard-129E). Each box was lined with plastic; twelve stacks, each stack having seven patties, were placed into the box. Individual patties were separated by wax paper. A sheet of wax paper was placed on top of the stacks, and another twelve stacks of patties were added. The plastic liner was then folded back to cover those patties, and the boxes were sealed and properly stenciled according to content and destination. Each box contained 168 patties with a net weight of 14.3 kg. It had been calculated that the 228.6 kg of ingredients (meat, soy protein, and water) would be sufficient to complete 16 boxes for each lot. Seven boxes were shipped to the U. S. Army Natick Laboratories in Massachusetts, and nine to the University of Maryland. All packed boxes were stored at -25 to -17 degrees centigrade until shipped.

Chemical Analysis of Soy Proteins

Proximate analysis of the soy proteins was performed according to procedures listed in The Association of Official Agricultural Chemists (Tenth Edition, 1965). All samples were randomly selected and homogenized for two minutes using a Sorvall Omni-mixer, and analyzed using A.O.A.C. procedures: Moisture (22.003), Ash (22.010), Fat (22.033), Protein (22.011), and Crude Fiber (22.038 .042.

Sampling Procedure

Boxes were placed in storage at -17°C. and stacked according to lot. Boxes in each lot were assigned numbers using a Table of Random Digits (Rohlf and Sokal, 1969), which enabled random selection of boxes for the tri-monthly storage studies with respect to location in freezer. Each tri-monthly study involved four samples, one sample consisted of two patties from each randomly selected box from each lot. Two samples were selected from the top half of the box, and two from the bottom half. There were twelve columns of patties in each half so the columns were assigned numbers

from one to twelve. Numbers from one to seven were assigned to patties in each column running from top to bottom of the column. Using a table of random digits, two patties from each selected column were randomly chosen. This provided four samples, each consisting of two patties from each lot. Boxes were resealed and replaced into storage.

Chemical Analysis of Patties

Samples for chemical analysis were homogenized in a Waring Blender for two minutes and prepared according to A.O.A.C. (23.001). Proximate analysis of patties from each lot was conducted after zero, three, six, nine and twelve months storage. Analyses were completed following A.O.A.C. procedures and included: Moisture (23.003), Ash (29.012), Fat (23.005), Protein (23.009), Peroxide Value (26.024 and 26.025). In addition, the Thiobarbituric Acid Test (TBA) for rancidity, was conducted using a distillation method by Tarlagdis et al (1960). The pH was determined with a Beckman[1/] Expandamatic pH Meter.

Organoleptic Evaluation

Samples for taste panels were randomly selected from the remaining patties in each box, in a fashion similar to that used for selection of patties for chemical analysis.

USDA - Panels

During each tri-monthly study a panel, comprised of 52 adults ranging from 18 to 60 years of age, was convened on Tuesday and Thursday evenings of the same week at intervals of 0, 3, 6, 9, and 12 months. Patties were cooked from the frozen state on a Hotpoint[1/] (230 watt) griddle at 177°C. for three minutes on each side, until the final pinkness at the center of the patty disappeared. The patties were then removed from the griddle and quartered. Four quartered pieces were randomly placed on a plate according to Plan 11.22 of Cochron and Cox (1957) and served to the panelists for evaluation. No condiments were added to the patties. Discussion of patties during evaluation was not permitted. Panelists were given scoring sheets (Fig. 1) and asked to evaluate each quarter for tenderness, flavor, appearance, aroma, juiciness, and overall acceptability. Each category was rated on a hedonic scale ranging from one to nine. Each numerical value had an associated verbal description ranging, for example, from extremely undesirable (1) to extremely desirable (9). A space for personal comments was provided.

In addition, a panel consisting of 13 employees of U.S.D.A. was convened at 11:00 a.m. and 2:30 p.m. on Tuesday and Thursday of the same week. The specific objective of this panel was to determine the affect of condiments on taste panel evaluation of the patties. Consequently, patties were served on the first day without condiments as in the evening panels, while patties on the second day were cooked with MSG, served on a bun with salt, pepper, pickles, mustard and catsup. Cola and potato chips were also served. Cooking, sampling and evaluation procedures were the same as for the evening panel.

Home - Family Panels

Two other panels, one consisting of 52 families with an average annual income over $10,000 and 52 families with an average annual income less than $10,000 evaluated patties that had been stored at -17°C. for six months. Instead of rating four quartered pieces simultaneously as done in the USDA panel, family members were asked to rate a different patty each week for four weeks. Each family was given an identification number and assigned four different types of patties using the same statistical design of Cochran and Cox (1957) used in the USDA panel. Each family was given one patty per family member.

Families were instructed to prepare the patties in any manner desired. Although patties and scoring sheets were provided for every member of the family, only data from family members above the age of nine were actually used in computations. Scoring sheets were identical to those used in the USDA panel, except there was an additional sheet of questions which provided information on the preparation of the patty and the effects of garnishments on rated variables (Figure 2).

RESULTS AND DISCUSSION

Chemical Analyses of Soy Proteins

Chemical composition of representative commercial textured soy protein and soy protein concentrates is presented in Table 1. Product identification has been coded A through F to protect the interests of participating manufacturers. The chemical composition of the soy protein products (Table 1) is very similar to the values provided to Batcher et al (1971) by the manufacturers. However, protein, ash, crude fiber and fat appear higher because these values are reported on a moisture free basis. If reported on a moisture present basis the percent protein for products A through F would be 53.82, 49.47, 49.90, 52.16, 65.10, and 64.52 respectively. It appears the soy protein concentrate from both manufacturers may be falling short of the advertised 70 percent protein.

Chemical Analyses of Fabricated Patties

Chemical analyses of fabricated patties was carried out each tri-monthly period to ensure that patties evaluated for palatability and acceptance by the panels, were substantially the same in proximate composition throughout the evaluation periods.

Ash. As shown in Table 2, patties containing concentrated soy protein and all beef patties had a lower ash content than patties containing textured products. Patties containing 30 percent soy protein had a higher concentration of ash than patties containing 20 percent. This simply reflected the increase in soy protein, which had a higher concentration of ash than the beef which the protein was replacing. Based on data collected over all months, the values for ash content ranged from a minimum of 0.80 (F - 20% and F-30%) to a maximum of 1.54% (A-30%).

Fat. During fabrication of patties, an attempt was made to maintain fat content relatively constant at 20.5% in all patties. However, on analyses of patties (Table 3) fat content was found to range over all months from a minimum value of 17.84% (F-30%) to a maximum of 24.16 (E-20%). These variations were interpreted as differences between lots of beef used in formulation of the patties. More precise control of fat content in the patties was not possible under the commercial conditions used in the study.

Moisture. Patties containing soy concentrates had a higher average content of moisture than the patties with textured soy (Table 4). This was expected since larger volumes of water were used to hydrate the concentrates. Value of moisture content ranged over all months from a minimum value of 54.17% (A-20%) to a maximum value of 61.55 (F-30%).

Protein. Protein content (Table 5) was relatively constant over all patties and ranged from a mimimum value of 15.91% (C-30%) to a maximum of 19.49% (all beef).

pH. The values for pH are given in Table 6. The patties containing 30% soy protein in general had a slightly higher pH than the all beef or the 20% patties. However, even when these differences were significant the magnitude of the difference was of no immediate importance. The minimum value observed was 5.39 (F-30%), while the maximum value was 6.39 (B-30%). Except for product F, all patties containing soy protein had a higher pH than the all beef patties.

TBA Number. The presence of malonaldehyde as an index of rancidity in the patties, is presented in Table 7. The highest initial value was recorded for all beef patties followed by F-30% and 20%. The lowest average value recorded was 0.4 for B-30%. Values over all months ranged from 0.474 to 5.471 (mg. malonaldehyde/100 gm. sample). Differences in TBA number could not be explained by classification of data into textured and concentrates, or 20% and 30%.

Lecithin, a long established antioxidant, is often added after fat extraction, for such purposes. This re-lecithination could be a major factor in differences in fat stability between products. Furthermore, variations in manufacturing procedures could have an effect on the stability of the naturally occurring lecithin present in the soy product. Another possibility is suggested in a study by Stevens et al (1970) on a lipoxygenase present in soybeans. The enzyme catalyzes the oxidation, by molecular oxygen, of cis-methylene interrupted unsaturated fatty acids and their esters to respective hydroperoxides. Maga and Johnson (1972) reported 40% less polyunsaturated fatty acids in soybean milk prepared by cold, than by hot-extraction procedures. A third factor is lipid degradation during preparation of the product. Fujimaki and co-workers (1965) stated that, during processing, chemical and physical factors such as decomposition of natural antioxidants; higher content of metal catalysts; and increased surface area, atmospheric oxygen, and humidity can accelerate lipid degradation.

Sessa et al (1969) concluded that some lipid degradation occurred in the preparation of defatted flakes and, more importantly, that characteristic soybean off-flavors were closely associated with certain lipids and their decomposition products.

Peroxide value. Peroxide values of the patties are shown in Table 8. The highest value recorded over all months is 11.79 milliequiv/kg. sample (F-30%), while the lowest value was 0.844 (D-30%). The greatest peroxide content was observed in all beef patties and F-30% as in the TBA analysis. The correlation between overall TBA and peroxide values was $r = .46$ and a coefficient of determination of $r^2 = 0.21$, indicating a rather poor relationship between the two procedures.

Recently, tests for peroxides have had very limited use due to the strict empirical nature of the methodology. Furthermore, the literature reports that although peroxide number may be used as an indication of lipid quality in early stages of deterioration, as oxidation proceeds the index becomes less reliable. This is due to the degradation of peroxides into numerous secondary products, including aldehydes, ketones, alcohols, and hydrocarbons. Additionally, the glyceride structure of the lipid has a great bearing on the peroxide value during oxidation. Triglycerides containing large quantities of polyunsaturated fatty acids such as those found in soybeans, that is, linoleic and linolenic, show a high initial peroxide content. Lastly, a distinct color change was not observed during titrations, making determinations rather difficult. Although this information certainly places considerable doubt on the data as being an actual representation of peroxide content and extent of lipid oxidation, it was noted that the higher values for peroxide were obtained on all beef and F-30% patties as was the case for the Thiobarbituric Acid Test. Rackis et al (1970) reported the presence of peroxidases in maturing soybeans, but these have not been investigated in relation to their effect on soy protein products.

The Effect of Box Location on Variables Studied

Average values of samples taken from the tops and bottoms of boxes, for all months and variables are shown in Table 9. Only the 6-month values showed any significant difference (moisture, TBA) between box location. However, combined analyses over all months indicated samples from the top had significantly less moisture content and significantly higher TBA and peroxide values when compared to corresponding patties from the bottom of the boxes. The magnitude of these differences, however, are so small that they are of questionable importance.

Organoleptic Evaluation - 52-Member Panel

Patties without condiments.

Flavor. Table 10 presents scores for flavor evaluation ranging over all months of storage, from 3.3 (F-30%) to 6.0 (all beef). Although all beef patties had the highest average rating, scores for patties containing 20% textured protein were not significantly lower. Scores for patties containing

30% soy protein were consistently lower than corresponding patties with 20% soy additives, however, the differences were not always statistically significant. Patties containing concentrates were scored significantly lower than those containing textured proteins. Sessa (1974) found that phospholipids in soybeans developed off-flavors when oxidized. For example, phosphatidylcholine developed a bitter taste with autoxidation. Accordingly, TBA values were correlated with flavor scores and the coefficient of correlation was found to be r = -.63. This indicates that lipid oxidation might be a contributing factor in flavor differences. Fine particle size might also have contributed to lower scores for concentrates. "Grainy, gritty and mealy" were frequent comments by panelists when describing patties containing soy protein additives. Overall, the best flavor was in the all beef patties, followed by patties containing textured soy protein at 20%, then 30%. Soy protein concentrate patties at 20% were still less flavorful and patties containing 30% soy protein concentrate were least flavorful. Some panelists detected rancidity in the nine and twelve month patties.

Appearance. Panel scores for appearance, presented in Table 11 ranged over all months from 4.2 (E-30%) to 6.3 (C-20%). Patties with 30% soy protein were generally scored lower than patties containing 20%, but the differences were only significant for concentrates. Patties containing textured soy protein product D consistently were rated lower than the other patties with textured protein, and at the 30% level of addition to patties the difference was significant. Patties with soy concentrates were significantly lower than patties with soy protein. Particle size, again, might be a factor in the lower scores for concentrates. Concentrates were finer and consequently caused the patty to have a grainy appearance.

Aroma. Scores for aroma evaluations, presented in Table 12, ranged from 3.9 (E-30%) to 6.1 (B-20%). Little variability was found among the patties containing textured soy proteins, even when 30% was compared to 20% patties. Patties containing soy protein concentrates were usually lower in aroma score than textured patties and all beef patties. This difference was often significant when patties contained 30% soy protein concentrate. Patties containing 20% soy protein concentrate were sometimes significantly lower in aroma score than patties with textured soy protein or all beef patties.

Juiciness. Juiciness scores for patties sampled during storage, listed in Table 13, ranged from 3.6 (F-30%) to 6.1 (A and C-30%). Patties containing textured soy protein consistently appeared to be more juicy than the all beef patties or the patties containing soy protein concentrates. The magnitude of the difference between all beef and soy concentrate patties though sometimes significant, was of questionable importance.

Tenderness. Tenderness values presented in Table 14 ranged from 3.5 (all beef) to 6.5 (D and B-30%). Patties with 30% textured protein, then 20%, had the highest scores, followed by soy protein concentrates at 30% then 20%. All-beef patties had the lowest average rating (4.1).

These data suggest differences in cooking losses between patties, since all beef patties were observed to have a greater cooking shrinkage than patties containing soy additives. A recent study by Judge et al (1974) indicates that shrinkage in patties was substantially reduced by soy additives. The effect of soy additives on cooking losses and tenderness of the cooked patties needs further study.

Overall acceptability. Overall acceptability scores presented in Table 15, range from 3.3 (E-30%) to 5.7 (B-20%). All beef patties and patties with textured soy protein usually were rated significantly higher than patties containing soy concentrates. On the average, patties containing 30% soy protein were scored lower than the corresponding patty with 20% soy protein; however, these differences were not always statistically significant. Though some panelists were able to detect rancidity in beef patties after prolonged storage (9 and 12 months), the all beef patties were rated about as good as, or better than the other patties tested.

The effect of storage on organoleptic quality. The average tri-monthly scores for each palatability trait are presented in Table 16. No decrease in score was observed for any trait measured. This supports chemical data which demonstrated no important chemical decomposition over the 12-month storage period. Although TBA values steadily increased with storage, only a few panelists could detect rancidity in the stored products. Six panelists evaluating the patties stored 12 months indicated an old or rancid flavor. A few panelist evaluating the patties after 9 months commented that the patties had exceeded their shelf life. Scores for some traits increased during the storage. It is conjectured that an initial prejudice to the product existed among the panelists but this gradually decreased during the study with a subsequent slight rise in the ratings.

Organoleptic Evaluation - 13-Member Panel

Evaluation of the effect of condiments on palatability traits of patties. Scores for flavor, aroma, tenderness and overall acceptability were significantly higher for patties served with condiments (Table 17) than patties served without condiments. There were no significant differences observed between patties in appearance. Scores for juiciness were somewhat lower for patties served with condiments, and might be due to the effect of the bun absorbing the juices.

Effect of Storage. Storage of the patties did not consistently affect panel evaluation scores. Scores of patties for appearance, aroma and overall acceptability were significantly higher after the 6-month storage as evaluated by the panel, however, there was no explanation for this difference. Where significant differences did occur the magnitude of the difference is so slight that the difference is of questionable importance.

Individual quality traits. Evaluation by the 13-member panel are presented in Tables 19-24. Some of the differences reported in the 52-member panel data may be more definitive than those presented in the six tables mentioned above because in these tables data from evaluation of patties with and without condiments has been combined.

Flavor. Patties containing soy concentrates were scored significantly lower than patties containing textured soy proteins (Table 19). All-beef patties were not significantly different from patties containing textured soy protein but were judged to be superior to patties containing soy protein concentrate at either the 20 or 30% level.

Appearance. Patties D, E, and F were found to be significantly lower in ratings than patties A, B, C, or the all beef patties (Table 20). All beef patties were not significantly different from patties with textured soy protein. The appearance of patties containing textured soy protein, brand D, was visibly less acceptable at 30% than the other patties containing textured soy protein or all beef.

Aroma. Patties containing soy protein concentrates were not always scored lower than patties with textured soy proteins (Table 21). No significant differences were observed between patties containing 20% and 30% of the additives, or between patties containing textured soy proteins and patties of all beef. Patties containing soy protein concentrates were rated significantly lower than patties of all beef.

Juiciness. Patties with concentrates usually were scored significantly lower than patties with textured soy protein (Table 22). There were no significant differences observed between 20% and 30% patties, or between all beef and patties containing textured soy additives.

Tenderness. Patties containing brand F of soy protein concentrate were scored significantly lower than all other patties in tenderness except the all-beef patties (Table 23). Patties containing 30% of brand B, C or D of textured soy protein were more tender ($P>0.05$) than patties containing 20%. All-beef patties were the toughest of all the patties evaluated. This may be explained in part by (a) patties containing soy protein appeared to retain more juices during cooking and (b) the cooking rate of all-beef patties appeared to be greater than patties containing soy additives. This area should be identified for additional research.

Overall Acceptability. Patties containing soy protein concentrates were significantly less acceptable than patties with textured protein or the all beef patties (Table 24). There were no significant differences between 20% and 30% concentrations or between all beef patties and those containing textured soy protein additives.

Organoleptic Evaluation - Home Panels -
Families having an average income in excess of $10,000.

Results of the evaluation of patties, that were stored for six months at -17°C. are presented in Table 25. The 52-family panel, after cooking and serving the patties as they customarily do with ordinary patties, detected no significant differences among any of the patties in flavor, appearance, aroma and overall acceptability. Scores ranged from 5.4 (D and F -30%) to

6.2 (A-20%) for flavor. Appearance was rated from 5.4 (D-30%) to 6.3 (C-30%). Scores for aroma ranged from 5.4 (F-30%) to 6.2 (B-20%). Evaluations of overall acceptability ranged from 4.9 (F-20% to 6.0 (B-20%).

There were some significant differences observed between patties rated on juiciness and tenderness. Scores for juiciness ranged from 4.1 (F-30%) to 5.5 (C-20% and C and E 30%). Patties with soy protein concentrate product F was scored significantly lower than most patties with textured soy protein additives. There was no difference between patties containing 20% and 30% textured soy proteins.

Tenderness scores ranged from a low of 4.7 (all beef) to 6.3 (A-30%). All beef patties usually were rated significantly lower than patties with any of the textured soy proteins.

Organoleptic Evaluation - Home Panels - Families having an annual income of less than $10,000

No significant differences were observed between patties in any of the palatability traits evaluated. Means for each trait were found to be significantly higher than the means from evaluations by panelists with higher incomes, indicating greater acceptability of the patties by lower income groups.

Comparison of U.S.D.A. and Home Panels. Since the patties for the home panels had been in storage for six months, a comparison was made between scores of the home panel and scores from the 6-month U.S.D.A. panel. Scores for appearance were higher in the home panel for all patties except D-30%. Flavor values were higher for all patties in the home panel except for B-20%. The home panel evaluations for aroma were again higher for all patties except all beef. Scores for juiciness were higher in the home panel for the concentrates and all beef patties, but lower for the patties with textured protein. Tenderness evaluations were similar to those in the U.S.D.A. panel. Results from the home panel indicated that all patties were found acceptable, and there was less distinction made among patties or concentrations. These differences probably reflect the use of condiments by the home panels. Also, only one type of patty was rated each week, and direct comparison between all four samples could not be made simultaneously as in the U.S.D.A. panel.

Cooking Method. A questionnaire concerning cooking procedures for the patties was given to family members on the home panel; replies showed no significant differences in tenderness, flavor, etc., due to cooking method, seasonings used while cooking, or the meal at which the patty was eaten. Significant differences were found for tenderness and juiciness due to the degree of doneness of the patty; patties cooked well done were found to be rated lower in tenderness and juiciness when compared to patties that were cooked rare.

The Effect of Age and Sex on Organoleptic Evaluations

Results of the home panel earning more than $10,000 listed according to sex and age are presented in Table 27. Although it was difficult to interpret

the data because of the uneven distribution in age groups, it was noted that in the younger age panelists tended to be more critical in their evaluations. Overall, the 20 - 29 age group was the most critical of all groups, while the 50 + age bracket were the least critical. There were no noticeable differences between the scores of males and females.

CONCLUSION

Patties containing 20 or 30% soy protein concentrates were less acceptable in flavor, appearance, aroma, juiciness and overall acceptability than all beef patties. Patties containing textured soy protein at 20% were about equal in palatability traits to all beef patties, whereas patties containing 30% textured soy protein tended to be detectably less acceptable than the all meat patties.

Patties stored at -17°C. developed increased malonaldehyde concentrations indicating lipid breakdown but the chemical tests for rancidity were not conclusive. Some panelists were able to detect rancidity during the nine and twelve-month storage. Soy protein additives tended to inhibit rancidity development.

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EVALUATION SHEET

Name_____ Age_____ Sex_____ Date_____ Code#_____

Circle the appropriate number for each characteristic of this study.

	TENDERNESS	FLAVOR	APPEARANCE	ODOR
1.	Extremely Tough	Extremely Undesirable	Extremely Undesirable	Extremely Undesirable
2.	Very Tough	Very Undesirable	Very Undesirable	Very Undesirable
3.	Moderately Tough	Moderately Undesirable	Moderately Undesirable	Moderately Undesirable
4.	Slightly Tough	Slightly Undesirable	Slightly Undesirable	Slightly Undesirable
5.	Slightly Tender	Slightly Desirable	Slightly Desirable	Slightly Desirable
6.	Moderately Tender	Moderately Desirable	Moderately Desirable	Moderately Desirable
7.	Tender	Desirable	Desirable	Desirable
8.	Very Tender	Very Desirable	Very Desirable	Very Desirable
9.	Extremely Tender	Extremely Desirable	Extremely Desirable	Extremely Desirable

COMMENTS:_____

	JUICINESS		OVERALL ACCEPTABILITY
1.	Extremely Dry	1.	I would eat this if forced to.
2.	Very Dry	2.	I would eat this if there were no other food choice
3.	Moderately Dry	3.	I would hardly ever eat this.
4.	Slightly Dry	4.	I don't like it but would eat it on occasion.
5.	Slightly Juicy	5.	I would eat this if available but would not go out of my way.
6.	Moderately Juicy	6.	I like this and would eat it now and then.
7.	Juicy	7.	I would frequently eat this.
8.	Very Juicy	8.	I would eat this very often.
9.	Extremely Juicy	9.	I would eat this every opportunity I had.

Comments:_____

Fig. 1. Criteria for panel evaluation of patties

1. How Cooked:
(Check One)

a. Pan fried _____
b. Broiled _____
c. Grilled _____
d. Other (Specify) _____

2. Seasonings Used While Cooking:
(Check One)

a. None _____
b. Salt _____
c. Pepper _____
d. MSG _____
e. Other (Specify) _____

3. Degree of Doneness:
(Check One)

a. Rare _____
b. Med. Rare _____
c. Med. _____
d. Well _____

4. When Eaten:
(Check One)

a. Lunch _____
b. Dinner _____
c. Snack _____
d. Other (Specify) _____

Briefly describe how patty was eaten. _____

_____

_____

_____

Examples: 1. On a roll with mustard, onions, potato chips and coke.

2. Patty was seasoned with salt and pepper and served with mashed potatoes, string beans and coffee.

Fig. 2. Questionnaire on cooking methods of beef patties for home panel.

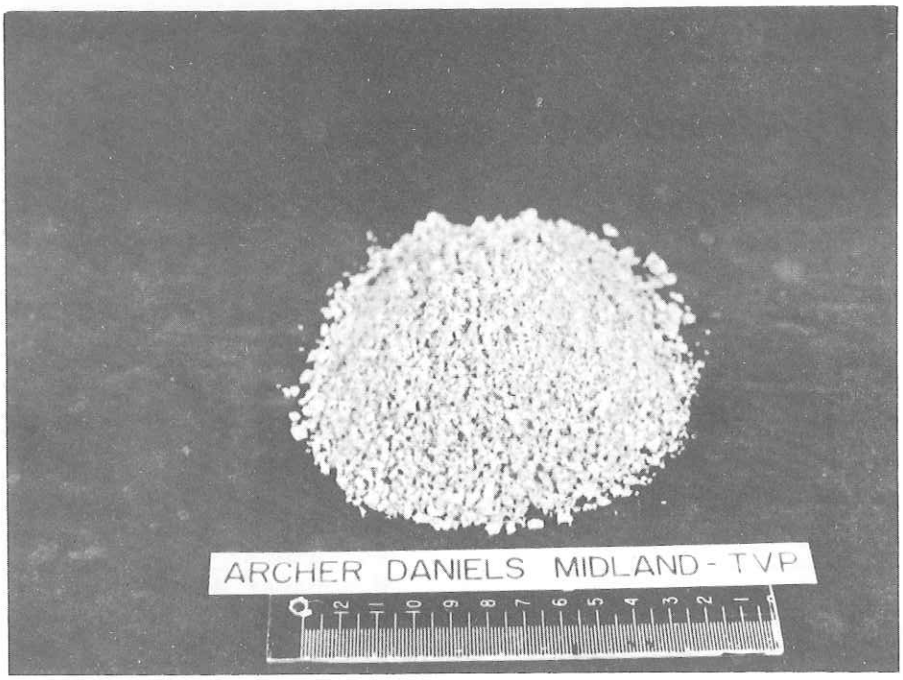

Photo 1. Archer Daniels Midland - Fortified TVP.

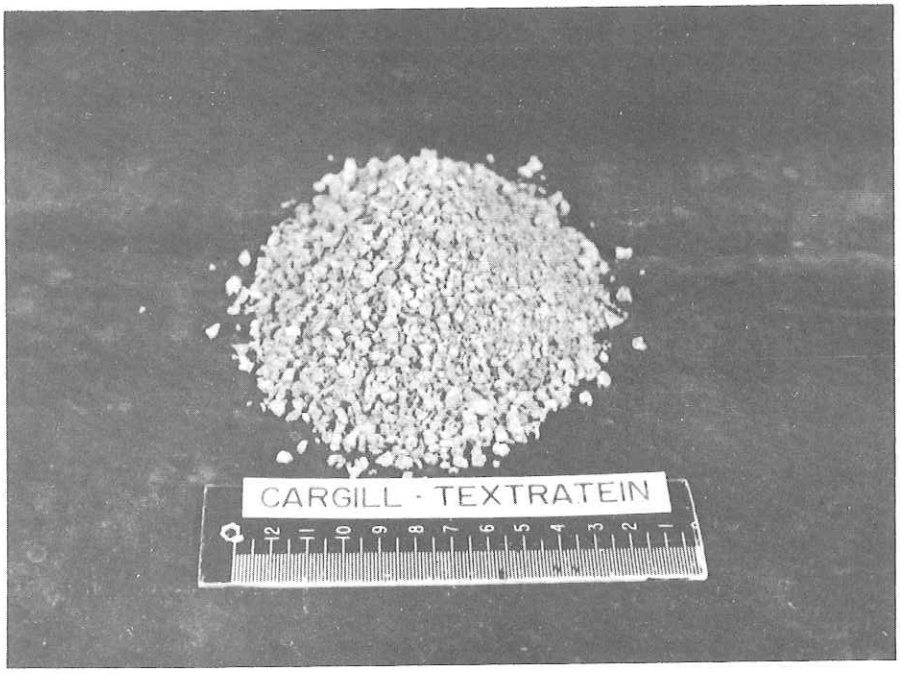

Photo 2. Cargill - Textratein.

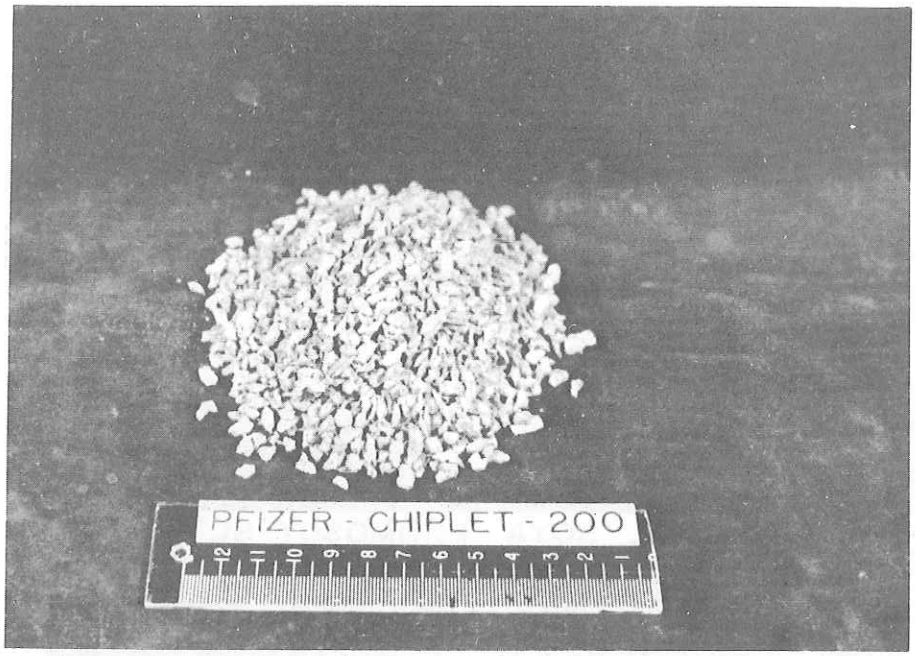

Photo 3. Pfizer - Chiplet - 200.

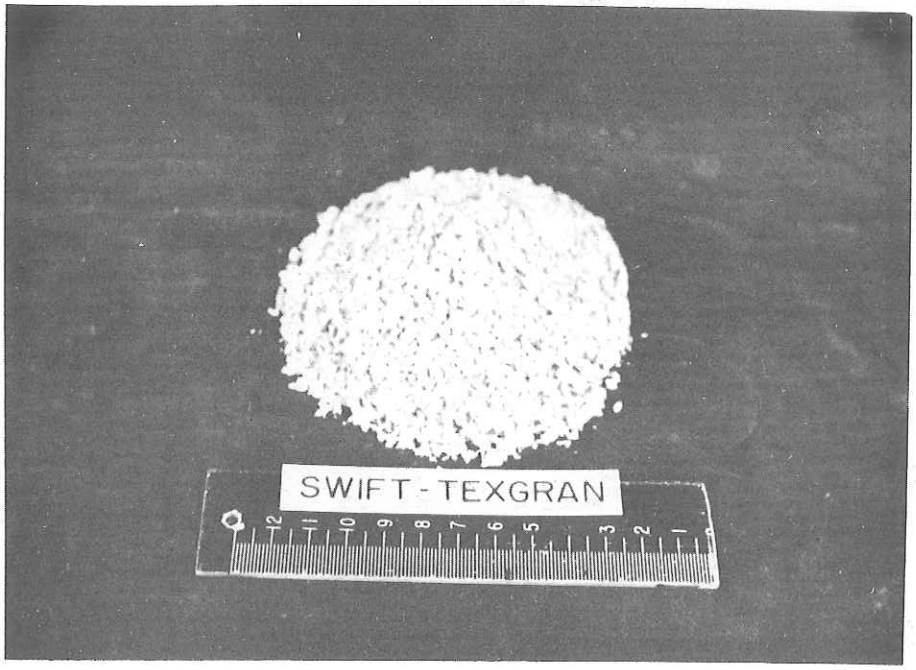

Photo 4. Swift - Texgran.

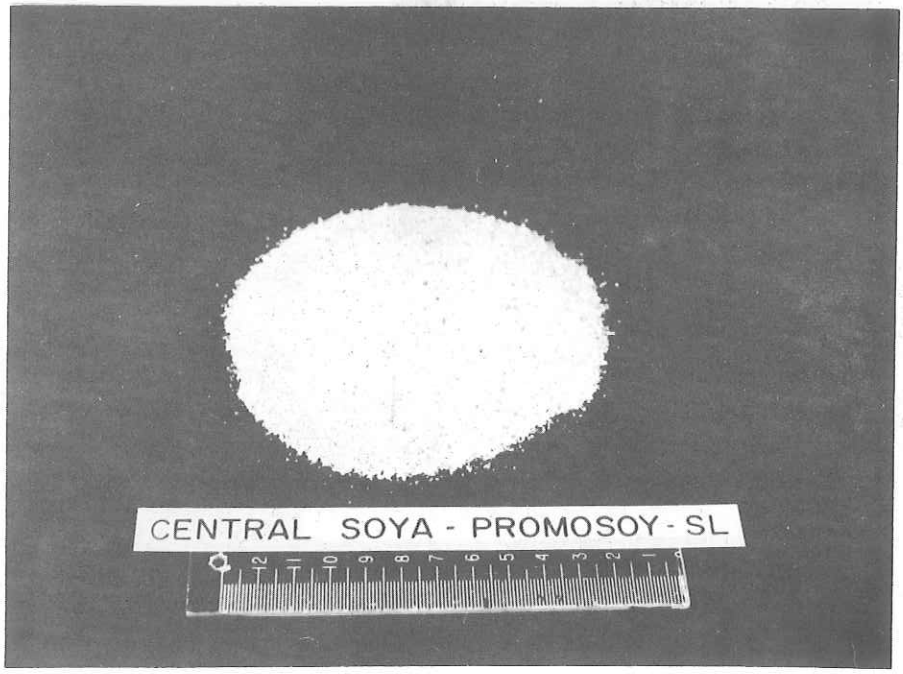

Photo 5. Central Soya - Promosoy - SL

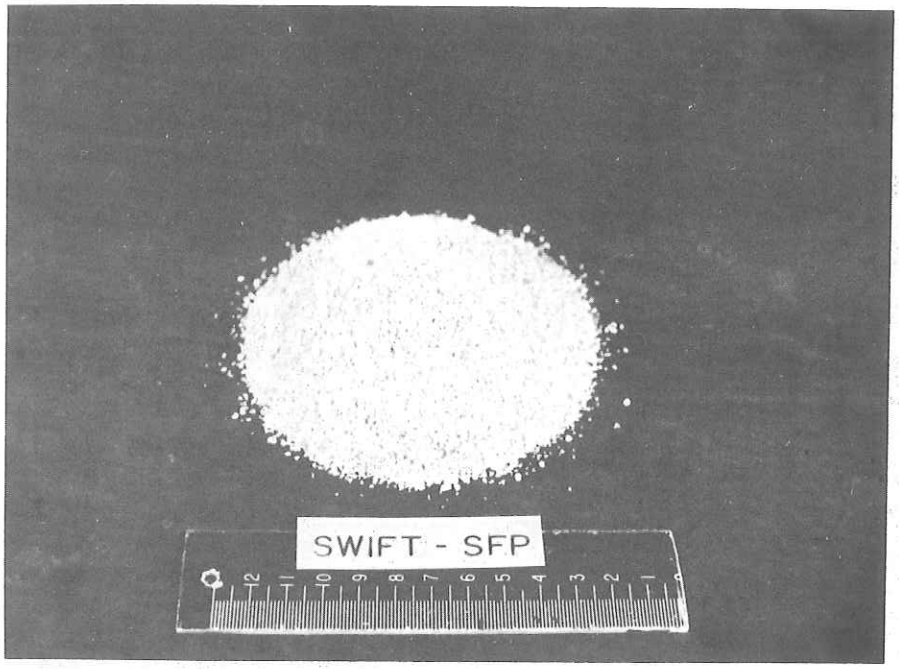

Photo 6. Swift - SFP.

Table 1. Soy protein composition

Soy Product	% Moisture	% Ash[a]	% Crude fiber[a]	% Fat[a]	% Protein[a]
Textured					
A	5.84 ± .01	6.96 ± .05	3.09 ± .13	0.61 ± .025	57.16 ± .26
B	8.13 ± .09	6.37 ± .02	2.72 ± .01	0.92 ± .002	53.85 ± .42
C	8.43 ± .01	6.23 ± .13	3.55 ± .09	0.49 ± .006	54.49 ± .39
D	7.46 ± .08	6.97 ± .05	4.49 ± .38	0.24 ± .020	56.36 ± .38
Concentrates					
E	7.08 ± .01	6.31 ± .05	6.65 ± .31	0.27 ± .009	70.06 ± .41
F	6.68 ± .02	4.04 ± .04	6.20 ± .08	0.35 ± .003	69.14 ± .48

[a] Calculated on a moisture-free basis.

Table 2. Ash content of patties during -17°C storage

Product	Month Storage[a] 0	3	6	9	12	Combined[b]
	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)
20% level						
Textured						
A	1.22 c	1.18 de	1.19 c	1.17 bcd	1.30 b	1.21 c
B	1.10 d	1.24 bcd	1.20 c	1.15 cd	1.16 de	1.17 d
C	1.10 d	1.10 ef	1.10 de	1.09 de	1.14 e	1.11 e
D	1.12 d	1.07 ef	1.14 cd	1.05 e	0.96 f	1.07 f
Concentrates						
E	0.99 d	1.04 fg	1.04 e	0.94 f	0.90 f	0.98 g
F	0.89 gh	0.89 h	0.88 f	0.82 g	0.80 g	0.86 h
30% level						
Textured						
A	1.37a	1.33ab	1.40a	1.32a	1.54a	1.39a
B	1.28 bc	1.32abc	1.22 c	1.24ab	1.28 bc	1.27 b
C	1.27 bc	1.25abcd	1.20 c	1.21 bc	1.21 cd	1.23 c
D	1.34ab	1.36a	1.31 b	1.21 bc	1.19 de	1.28 b
Concentrates						
E	1.04 de	1.21 cd	1.02 e	1.02 e	0.90 f	1.04 f
F	0.95 fg	0.94 gh	0.89 f	0.85 g	0.80 g	0.89 h
All Beef	0.86 h	0.88 h	0.88 f	0.84 g	0.96 f	0.88 h

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to the analysis of variance and Duncan's Multiple Range test (1955).

[b] Mean storage value for all months.

Table 3. Fat content of patties during -17°C storage

Product	Month Storage[a] 0	3	6	9	12	Combined[b]
	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)
20% level						
Textured						
A	21.38abcd	22.31abc	20.62 cde	21.12 cd	22.02 b	21.09 def
B	20.52 e	19.95 ef	19.22 ef	18.39 e	18.74 d	19.36 h
C	22.66ab	22.52ab	22.91abcde	20.99 cde	22.85 b	22.39 bc
D	21.91abcde	22.05abc	20.56 de	20.99 cd	21.84 bc	21.47 def
Concentrates						
E	23.38a	22.96a	23.36a	23.17a	24.16a	23.41a
F	21.43 bcde	21.73 bcd	20.15 e	20.00 d	19.11 d	20.48 g
30% level						
Textured						
A	20.72 de	21.18 cd	20.77 cde	21.91 bc	22.65 b	21.45 ef
B	21.75abcde	22.85abc	21.78 bcd	21.04 cd	22.47 b	21.98 cd
C	22.97ab	22.82abc	22.38ab	22.69ab	23.30 b	22.83 b
D	22.32abcd	20.79 de	22.14abc	21.22 c	21.87ab	21.67 de
Concentrates						
E	22.46abc	21.92abcd	22.03abcd	22.08abc	22.47 b	22.19 bc
F	18.08 f	18.95 f	17.87 f	17.84 e	19.11 d	18.37 i
All Beef	21.23 cde	21.24 cd	20.77 cde	21.04 cd	20.61 c	20.98 f

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955).

[b] Mean storage value for all months.

Table 4. Moisture content of patties during -17°C storage

Product	Month Storage[a] 0	3	6	9	12	Combined[b]
	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)
20% level Textured						
A	54.17 g	55.46 efg	57.22 de	56.28 h	57.07 cd	56.04 gh
B	57.48 bcd	56.86 cde	58.70 c	59.30 bc	58.93abc	58.25 c
C	56.30 def	56.06 de	56.28 ef	57.22 efg	56.33 cd	56.44 fg
D	55.08 efg	56.41 cde	57.07 de	58.08 de	57.69 bcd	56.87 ef
Concentrates						
E	56.98 cde	57.08 cd	57.76 cd	57.72 ef	57.36 cd	57.38 de
F	59.41 b	59.25 b	60.08 b	59.98 b	61.45a	60.04 b
30% level Textured						
A	55.28 efg	54.49 fgh	56.02 fg	55.67 hi	55.97 cd	55.51 hi
B	54.44 fg	54.18 gh	55.23 fg	55.24 i	54.79 d	54.77 j
C	55.17 efg	53.99 h	55.88 fg	54.95 i	55.97 cd	55.19 ij
D	54.84 fg	55.66 def	55.13 g	56.92 fg	56.12 cd	55.73 hi
Concentrates						
E	56.98 cde	57.78 c	58.71 c	58.07 de	56.06 cd	57.52 d
F	61.50a	61.41a	61.49a	61.40a	61.55a	61.41a
All Beef	58.37 bc	60.30ab	59.75 b	58.96 cd	60.49ab	59.57 b

a Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to the analysis of variance and Duncan's Multiple Range Test (1955).

b Mean storage value for all months.

Table 5. Protein content of patties during -17°C storage

Product	Month Storage[a] 0	3	6	9	12	Combined[b]
	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)
20% level						
Textured						
A	18.79a	18.00a	17.50abc	16.78ab	18.82a	17.98a
B	18.21ab	16.71 d	17.43abc	17.27a	18.34a	17.61ab
C	17.54abc	17.37abcd	17.06 cde	16.65 bc	18.03a	17.33 bc
D	16.90 bcd	17.02 cd	17.29 bc	16.90ab	18.15a	17.25 bc
Concentrates						
E	16.68 bcd	17.54abc	16.21 f	15.98 de	18.09a	16.90 cd
F	16.98 bcd	17.74abc	17.22 bcd	16.48 bcd	18.69a	17.42 bc
30% level						
Textured						
A	17.90ab	17.74abc	17.64ab	16.12 cde	18.20a	17.52ab
B	17.50abc	17.32abcd	17.24 bcd	16.87ab	18.09a	17.40 bc
C	16.28 cd	16.66 d	16.63 ef	15.91 e	18.04a	16.70 d
D	17.60abc	17.92ab	17.22 bcd	16.53 bcd	18.42a	17.54ab
Concentrates						
E	16.98 bcd	17.74abc	17.22 bcd	16.48 bcd	18.56a	17.40 bc
F	17.92ab	17 18 bcd	17.95a	16.52 bcd	18.69a	17.65ab
All Beef	17.71abc	18.05a	17.98a	17.01ab	19.49a	18.05a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955).

[b] Mean storage value for all months.

Table 6. pH of patties

Product	Month Storage[a] 0	3	6	9	12	Combined[b]
20% level						
Textured						
A	6.10 bc	6.15 d	6.14 cd	6.17 cd	6.00 de	6.11 e
B	6.07 c	6.25 c	6.09 e	6.18 cd	5.98 e	6.11 e
C	5.94 e	6.14 d	6.08 e	6.13 d	6.05 cde	6.07 f
D	6.01 d	6.15 d	6.11 de	6.17 cd	6.05 cde	6.10 ef
Concentrates						
E	6.05 c	6.26 c	6.07 e	6.24 b	6.14abc	6.15 d
F	5.48 g	5.64 e	5.77 g	5.67 f	5.50 g	5.61 h
30% level						
Textured						
A	6.20a	6.32 b	6.20ab	6.30a	6.12 bcd	6.23ab
B	6.20a	6.39a	6.24a	6.27ab	6.17abc	6.25a
C	6.11 b	6.30 b	6.18 bc	6.22 bc	6.25a	6.21 bc
D	6.16a	6.29 bc	6.17 bc	6.23 b	6.04 cde	6.18 cd
Concentrates						
E	6.19a	6.38a	6.18 bc	6.24 b	6.23ab	6.24ab
F	5.39 h	5.64 e	5.58 h	5.48 g	5.52 g	5.52 i
All Beef	5.78 f	6.11 d	5.83 f	5.95 e	5.75a	5.88 g

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955).

[b] Mean storage value for all months.

Table 7. Concentration of malonaldehyde as determined by Thiobarbituric Acid Test[a] in patties during -17°C. storage

Product	Month Storage[b] 0	3	6	9	12	Combined[c]
20% level						
Textured						
A	0.78 ef	1.42 fg	1.92 def	2.25 de	3.31 b	1.94 ef
B	0.71 ef	1.02 gh	1.40 f	1.46 g	2.93 bc	1.50 i
C	1.22 cde	1.60 ef	2.26 de	1.84 f	2.85 bcd	1.95 ef
D	0.93 def	1.88 cdef	1.96 def	2.40 d	2.42 de	1.92 ef
Concentrates						
E	1.55 bc	2.13 cd	2.38 d	2.00 ef	2.14 ef	2.04 de
F	1.54 bc	2.28 c	3.39 c	5.00 b	5.04a	3.45 c
30% level						
Textured						
A	0.76 ef	1.44 fg	1.72 ef	1.69 fg	2.52 cde	1.63 gh
B	0.47 f	0.61 h	0.73 g	0.90 h	1.43 g	0.83 j
C	1.09 cde	1.48 fg	1.59 f	1.72 fg	1.91 f	1.56 hi
D	1.39 cd	2.05 cde	2.47 d	2.38 d	2.81 cd	2.22 d
Concentrates						
E	1.08 cde	1.68 def	1.99 def	1.94 f	2.24 ef	1.79 fg
F	2.03 b	2.73 b	4.15 b	4.40 c	5.13a	3.69 b
All Beef	4.03a	4.07a	5.47a	5.39a	4.84a	4.76a

a mg./kg sample.

b Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955).

c Mean storage value for all months.

Table 8. Peroxide values[a] of patties during -17°C storage

Product	Month Storage[b] 0	3	6	9	12	Combined[c]
20% level						
Textured						
A	2.73 b	1.05 c	2.17 cde	1.62 d	4.06 cd	2.33 e
B	2.49 b	1.04 c	1.66 e	1.52 d	2.22 de	1.79 h
C	2.10 b	2.64a	2.60 cd	3.14a	3.37 cde	2.77 d
D	2.02 b	0.86 c	1.79 de	1.45 d	4.38 c	2.10 efg
Concentrates						
E	2.51 b	1.06 c	1.75 e	1.86 bcd	2.04 e	1.84 gh
F	2.39 b	2.31a	5.33 b	2.78a	8.66 b	4.29 b
30% level						
Textured						
A	2.11 b	1.33 bc	2.71 c	1.58 d	2.31 de	2.01 fgh
B	2.53 b	1.32 bc	1.81 de	2.21 b	2.34 de	2.04 efgh
C	2.41 b	2.68a	2.23 cde	1.71 cd	2.20 de	2.25 ef
D	2.55 b	0.84 c	2.14 cde	1.53 d	2.45 de	1.90 gh
Concentrates						
E	2.79 b	1.64 b	1.57 e	2.07 bc	3.56 cde	2.33 e
F	4.36a	2.63a	7.88a	2.96a	11.79a	5.92a
All Beef	2.05 b	1.80 b	4.88 b	2.06 bc	7.32 b	3.62 c

[a] Milliequiv. peroxide/kg. sample

[b] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955).

[c] Mean storage value for all months.

Table 9. Effect of location in box on composition and rancidity[a]

Location in box	Ash (percent)	Fat (percent)	Moisture (percent)	Protein (percent)	pH	TBA # mg/kg	Peroxide mg/kg
Month 0							
Top	1.11a	21.62a	56.49a	17.26a	5.98a	1.44a	2.54a
Bottom	1.12a	21.57a	56.74a	17.47a	5.97a	1.27a	2.55a
Month 3							
Top	1.14a	21.76a	56.84a	17.46a	6.16a	1.90a	1.72a
Bottom	1.13a	21.43a	56.84a	17.40a	6.16a	1.85a	1.54a
Month 6							
Top	1.13a	21.37a	57.44 b	17.18a	6.05a	2.54a	2.93a
Bottom	1.10a	20.87a	57.84a	17.29a	6.05a	2.29 b	3.00a
Month 9							
Top	1.08a	21.00a	57.59a	16.57a	6.10a	2.61a	2.10a
Bottom	1.07a	20.98a	57.76a	16.49a	6.09a	2.52a	1.97a
Month 12							
Top	1.09a	21.46a	57.48a	18.64a	5.97a	3.09a	4.68a
Bottom	1.09a	21.64a	57.89a	18.22a	5.99a	3.00a	4.05a
Average							
Top	1.11a	21.44a	57.17 b	17.42a	6.05a	2.31a	2.79a
Bottom	1.10a	21.30a	57.41a	17.37a	6.05a	2.19 b	2.62 b

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955).

Table 10. Flavor of patties, without condiments, evaluated by a 52-member consumer panel[a]

Product	Month Storage 0	3	6	9	12	Combined[b]
20% level						
Textured						
A	5.5a	5.5ab	5.6ab	5.2abcd	5.2ab	5.4ab
B	4.8abcd	5.6a	5.9a	5.7ab	5.3a	5.5ab
C	5.3ab	4.5 cde	5.3abc	5.4abc	5.5a	5.2abc
D	4.8abcd	5.7a	5.6ab	5.1 bcde	5.5a	5.3abc
Concentrates						
E	4.0 def	3.6 f	4.2 de	4.3 efg	3.8 c	4.0 gh
F	4.0 def	4.1 def	4.1 de	4.4 def	4.7abc	4.3 fg
30% level						
Textured						
A	5.0abc	4.9abcd	4.8 bcd	5.4abc	5.5a	5.1 bcd
B	4.5 bcd	4.2 def	4.5 cde	5.2abcd	4.7abc	4.6 ef
C	4.7abcd	5.6ab	4.9 bcd	4.6 cdef	4.9ab	4.9 cde
D	4.3 cde	4.7 bcde	4.6 cd	5.3abc	4.7abc	4.7 de
Concentrates						
E	3.6 ef	3.8 ef	3.7 e	3.5 g	4.3 bc	3.8 h
F	3.3 f	3.6 f	3.6 e	4.0 fg	3.9 c	3.7 h
All Beef	5.4a	5.1abc	6.0a	6.0a	5.6a	5.6a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value is based on 32 determinations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

[b] Mean storage value for all months.

Table 11. Appearance of patties, without condiments, evaluated by a 52-member consumer panel[a]

Product	Month Storage 0	3	6	9	12	Combined[b]
20% level						
Textured						
A	5.9a	5.9a	5.9a	6.2a	5.9ab	6.0a
B	5.4ab	6.1ab	6.1a	6.0ab	5.9ab	6.0a
C	5.5ab	6.0ab	5.5ab	6.1ab	6.3a	5.9a
D	5.3abc	5.7ab	4.7a	5.8ab	5.2 bcd	5.3 bc
Concentrates						
E	5.1abc	4.8 de	4.8 bcd	5.6ab	5.2 bcd	5.1 c
F	4.7 cd	5.4 bcd	5.3abc	5.6ab	5.4abc	5.3 c
30% level						
Textured						
A	5.5ab	5.8ab	5.6a	6.0ab	5.6abc	5.7ab
B	5.8a	5.6 bc	5.8a	5.8ab	5.9ab	5.8a
C	5.5ab	6.3a	5.8a	6.0ab	5.6abc	5.8a
D	4.8 bcd	4.9 cde	4.7 cd	5.4 bc	4.5 d	5.1 c
Concentrates						
E	4.4 d	4.2 f	4.5 d	4.2 d	4.9 cd	4.4 d
F	4.7 cd	4.6 ef	4.4 d	4.9 c	4.5 d	4.6 d
All Beef	5.7a	5.5 bc	5.9a	6.2a	5.6abc	5.8a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value is based on 32 determinations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

[b] Mean storage value for all months.

Table 12. Aroma of patties, without condiments, evaluated by a 52-member consumer panel[a]

Product	Month Storage 0	3	6	9	12	Combined[b]
20% level						
Textured						
A	6.0a	5.7ab	5.7a	5.7a	5.9a	5.8a
B	5.3abcdef	5.6ab	6.1a	5.7a	5.5ab	5.6a
C	5.9ab	5.6ab	5.7a	5.8a	6.0a	5.8a
D	5.6abc	5.7ab	5.6a	5.5ab	5.6ab	5.6a
Concentrates						
E	4.8 def	5.1 bc	4.7 bc	5.3ab	4.7 cd	4.9 c
F	4.8 ef	5.1 bc	4.9 bc	4.9 bc	5.0 bcd	4.9 c
30% level						
Textured						
A	5.2 bcdef	5.4ab	5.5ab	5.7a	5.9a	5.5ab
B	5.5abcd	5.2abc	5.4ab	5.7a	5.7ab	5.5ab
C	5.4abcde	5.9a	5.8a	5.5ab	5.5ab	5.6a
D	5.0 cdef	5.2 bc	5.4ab	5.5ab	5.0 bcd	5.2 bc
Concentrates						
E	4.9 cdef	3.9 d	4.4 c	4.2 d	5.0 bcd	4.5 d
F	4.6 f	4.5 cd	4.4 c	4.3 cd	4.5 d	4.5 d
All Beef	5.5abcd	5.3ab	6.0a	6.0ab	5.4abc	5.6a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value is based on 32 determinations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

[b] Mean storage value for all months.

Table 13. Juiciness of patties, without condiments, evaluated by a 52-member consumer panel[a]

Product	Month Storage 0	3	6	9	12	Combined[b]
20% level						
Textured						
A	5.6a	5.1 cde	5.6ab	5.0 bc	5.4ab	5.3ab
B	4.7 bcde	5.3 bcd	5.4ab	5.2 bc	5.2abc	5.2 bc
C	5.0abcd	4.9 de	5.7a	5.3 bc	5.6ab	5.3abc
D	4.7 bcde	6.0ab	5.1abc	4.8 bcd	4.8 bcd	5.1 bc
Concentrates						
E	4.3 def	4.5 ef	4.6 cd	4.6 cd	4.3 d	4.5 de
F	4.2 ef	4.4 ef	3.8 e	4.7 bcd	5.1 bcd	4.4 de
30% level						
Textured						
A	5.1abc	5.8abc	5.6a	6.1a	6.0a	5.7a
B	5.1ab	5.8abc	5.3abc	5.5ab	5.4ab	5.4ab
C	5.0abcd	6.1a	5.7a	5.3 bc	5.6ab	5.5ab
D	5.2ab	5.4abcd	4.9 bc	5.0 bc	5.6ab	5.2 bc
Concentrates						
E	3.7 f	4.3 ef	4.8 bc	4.7 bcd	4.5 cd	4.4 e
F	3.6 f	4.0 f	4.0 de	4.2 d	4.3 d	4.0 e
All Beef	4.3 def	4.8 de	4.9 bc	4.7 bcd	5.6ab	4.9 cd

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value is based on 32 determinations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

[b] Mean storage value for all months.

Table 14. Tenderness of patties, without condiments, evaluated by a 52-member consumer panel[a]

Product	Month Storage 0	3	6	9	12	Combined[b]
20% level						
Textured						
A	6.3a	5.3 bcd	5.6abc	5.4 bc	5.0ab	5.6 bc
B	4.8 d	5.4 bcd	6.4abc	5.3 bcd	5.0ab	5.3 cd
C	5.3 bc	5.8ab	5.7abc	5.0 cd	5.4a	5.4 bc
D	4.8 cd	5.7abc	5.6 bc	5.1 bcd	4.8abc	5.2 cd
Concentrates						
E	4.6 d	5.2 bcd	4.7 de	4.8 cd	3.9 cd	4.8 de
F	4.5 de	4.2 e	4.1 e	4.6 de	4.2 bcd	4.4 ef
30% level						
Textured						
A	5.9ab	5.9ab	6.3ab	6.2a	6.4a	6.1a
B	6.0ab	6.4a	6.4a	6.5a	6.0ab	6.3a
C	6.1a	6.4a	6.1abc	5.1 cd	4.3 bcd	5.9ab
D	5.9ab	6.5a	5.4 cd	5.9ab	5.8abc	5.9ab
Concentrates						
E	5.6a	5.0 cd	5.8abc	5.0 cd	3.8 d	5.3 cd
F	4.8 cd	4.6 de	4.7 de	4.1 ef	4.1 f	4.5 ef
All Beef	3.8 e	4.1 e	4.6 de	3.5 f	4.3 f	4.1 f

[a]Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value is based on 32 determinations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.
[b]Mean storage value for all months.

Table 15. Overall acceptability of patties, without condiments, evaluated by a 52-member consumer panel[a]

Product	Month Storage 0	3	6	9	12	Combined[b]
20% level Textured						
A	5.1a	5.1a	5.4abc	5.0a	5.0ab	5.1a
B	4.5abc	5.0ab	5.7a	5.2a	5.0ab	5.1a
C	5.0a	4.6abc	5.0abc	4.8ab	5.4a	5.0ab
D	4.7a	5.3a	4.9abc	4.7ab	4.8abc	4.9ab
Concentrates						
E	3.8 cd	4.0 cd	3.9 d	4.0 bcd	3.9 cd	3.9 de
F	3.8 cd	4.0 cd	3.9 d	4.4abc	4.2 bcd	4.1 d
30% level Textured						
A	4.6ab	4.6abc	4.7 c	5.1a	5.4a	4.9ab
B	4.7a	4.1 cd	4.7 bc	5.1a	4.5abcd	4.6 bc
C	4.3abc	5.1a	4.8 bc	4.5abc	4.3 bcd	4.6 bc
D	3.9 bcd	4.2 bcd	4.7 bc	4.9a	4.4abcd	4.4 c
Concentrates						
E	3.5 d	3.7 d	3.5 d	3.3 d	3.8 d	3.6 e
F	3.4 d	3.7 d	3.4 d	3.7 cd	3.8 d	3.6 e
All Beef	5.0a	4.7abc	5.5ab	5.1a	5.1ab	5.1a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value is based on 32 determinations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

[b] Mean storage value for all months.

Table 16. Effect of storage on organoleptic traits of all frozen patties[a]

Month in storage	Tenderness	Flavor	Appearance	Aroma	Juiciness	Overall acceptability
0	5.3ab	4.6 b	5.2 b	5.3a	4.6 b	4.3 b
3	5.4ab	4.7ab	5.4ab	5.2a	5.1a	4.5ab
6	5.5a	4.8a	5.4 b	5.4a	5.0a	4.6a
9	5.1 b	4.9a	5.7a	5.4a	5.0a	4.6a
12	5.2 b	4.9a	5.4 b	5.4a	5.2a	4.6a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

Table 17. Influence of condiments on acceptability of patties, evaluated by a 13-member panel[a]

	Flavor	Appearance	Aroma	Juiciness	Tenderness	Overall acceptability
Without condiments						
Morning	4.3 b	5.3a	5.0 b	4.9a	4.7 b	4.2 b
Afternoon	4.2 b	5.2a	5.0 b	4.6ab	4.8 b	4.2 b
With Condiments						
Morning	5.0a	5.1a	5.4a	4.4 b	5.3a	4.8a
Afternoon	5.1a	5.2a	5.6a	4.5 b	5.4a	4.9a

[a] Values within a column followed by the same letter or letters were not significantly different ($P>0.05$) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value was based on 260 evaluations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

Table 18. Effect of storage on organoleptic traits of all frozen patties, evaluated by a 13-member panel[a]

Month in storage	Flavor	Appearance	Aroma	Juiciness	Tenderness	Overall acceptability
0	4.4 b	5.0 b	5.3 b	4.5a	5.2a	4.5 b
3	4.7a	5.1 b	5.2 b	4.6a	5.0ab	4.4 b
6	4.9a	5.6a	5.6a	4.7a	5.0ab	4.9a
9	4.8a	5.1 b	5.1 b	4.7a	4.8 b	4.6 b
12	4.5ab	5.2 b	5.1 b	4.6a	5.1a	4.3 b

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value was based on 208 evaluations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

Table 19. Flavor of patties, evaluated by a 13-member panel[a]

Product	Treatment		Combined
	20%	30%	
A	5.0ab	4.8abcd	4.9a
B	5.2a	4.6abcde	4.9a
C	5.0abc	5.1ab	5.0a
D	4.8abcd	4.5abcde	4.7a
E	4.3 cde	4.1 de	4.2 b
F	4.3 bcde	3.9 c	4.1 b
All Beef	4.9a	4.9a	4.9a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value was based on 80 evaluations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

Table 20. Appearance of patties, evaluated by a 13-member panel[a]

	Treatment		Combined
	20%	30%	
A	5.6ab	5.4ab	5.5a
B	5.7ab	5.4ab	5.5a
C	5.7ab	5.9a	5.8
D	5.2 bc	4.7 cd	4.9 b
E	5.1 bc	4.2 d	4.7 b
F	5.3abc	4.4 d	4.8 b
All Beef	5.3a	5.3a	5.3a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value was based on 80 evaluations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

Table 21. Aroma of patties, evaluated by a 13-member panel[a]

	Treatment		Combined
	20%	30%	
A	5.5a	5.5ab	5.5a
B	5.7a	5.4ab	5.6a
C	5.5ab	5.8a	5.6a
D	5.3ab	5.2ab	5.3a
E	4.9 bc	4.9 bc	4.9 b
F	4.9 bc	4.4 c	4.7 b
All Beef	5.1a	5.1a	5.1a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value was based on 80 evaluations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

Table 22. Juiciness of patties, evaluated by a 13-member panel[a]

	Treatment		Combined
	20%	30%	
A	4.7abc	4.9a	4.8a
B	4.5abcd	4.9ab	4.7a
C	4.7abc	5.0a	4.8a
D	4.8abc	5.0a	4.9a
E	4.3 bcd	4.3 cd	4.3 b
F	4.1 d	4.0 d	4.1 b
All Beef	4.6a	4.6a	4.6a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value was based on 80 evaluations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

Table 23. Tenderness of patties, evaluated by a 13-member panel[a]

	Treatment		Combined
	20%	30%	
A	5.2 bcd	5.7ab	5.4a
B	5.1 bcd	6.0a	5.5a
C	4.8 de	5.6ab	5.2a
D	4.9 cde	5.6ab	5.2a
E	4.9 cde	5.5abc	5.2a
F	4.2 f	4.4 ef	4.3 b
All Beef	3.8 b	3.8 b	3.8 b

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value was based on 80 evaluations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

Table 24. Overall acceptability of patties, evaluated by a 13-member panel[a]

	Treatment		Combined
	20%	30%	
A	4.8ab	4.7abc	4.7a
B	5.0a	4.6abcd	4.8a
C	4.7ab	4.9ab	4.8a
D	4.6abcd	4.4 bcde	4.5a
E	4.2 cde	3.9 e	4.0 b
F	4.1 de	3.9 e	4.0 b
All Beef	4.8a	4.8a	4.8a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value was based on 80 evaluations. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

Table 25. Organoleptic evaluation, 52-member home panel earning over $10,000[a]

Product	Tenderness	Flavor	Appearance	Aroma	Juiciness	Overall acceptability
20% level						
Textured						
A	5.8ab	6.2a	6.1a	6.0a	5.2ab	5.6a
B	6.0ab	5.8a	6.2a	6.2a	5.4a	6.0a
C	5.9ab	5.9a	6.0a	6.1a	5.5ab	5.4a
D	5.6abc	5.9a	6.2a	5.9a	5.3ab	5.4a
Concentrates						
E	5.1 bc	5.9a	6.2a	6.0a	4.7abc	5.6a
F	5.1 bc	5.6a	5.7a	5.6a	4.3 bc	4.9a
30% level						
Textured						
A	6.3a	5.5a	6.0a	5.7a	5.3ab	5.4a
B	5.8ab	5.9a	6.1a	5.9a	5.2ab	5.2a
C	5.9ab	6.1a	6.3a	5.9a	5.5a	5.4a
D	5.7ab	5.4a	5.4a	5.6a	4.9abc	5.4a
Concentrates						
E	6.2a	6.0a	5.9a	6.1a	5.5a	5.1a
F	5.0 bc	5.4a	5.7a	5.4a	4.1 c	5.0a
All Beef	4.7 c	6.0a	6.1a	5.8a	4.7abc	5.9a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance and Duncan's Multiple Range Test (1955). Each value is based on the evaluation of 16 families. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

Table 26. Organoleptic evaluation, 52-family home panel earning under $10,000[a]

Product	Tenderness	Flavor	Appearance	Aroma	Juiciness	Overall acceptability
20% level						
Textured						
A	6.4a	6.7a	6.5a	6.4a	6.3a	6.2a
B	6.2a	6.7a	6.6a	6.4a	5.8a	6.2a
C	6.3a	6.4a	6.6a	7.1a	6.0a	6.4a
Concentrates						
E	6.7a	6.7a	6.7a	6.5a	6.3a	6.9a
F	6.4a	6.1a	6.0a	6.4a	6.3a	6.3a
30% level						
Textured						
A	6.4a	5.9a	6.0a	6.6a	5.9a	6.0a
B	6.9a	6.7a	7.0a	6.3a	5.9a	6.7a
C	5.9a	5.7a	6.0a	6.1a	6.0a	5.5a
D	6.2a	6.2a	6.2a	6.0a	5.5a	6.4a
Concentrates						
E	6.3a	6.2a	6.7a	6.4a	5.9a	6.5a
F	6.5a	6.1a	6.3a	6.7a	5.9a	5.9a
All Beef	6.4a	6.8a	7.0a	6.7a	5.9a	6.7a

[a] Values within a column followed by the same letter or letters were not significantly different (P>0.05) according to analysis of variance of Duncan's Multiple Range Test (1955). Each value is based on the evaluation of 16 families. Scores were based on a 9-point hedonic scale, 1-poorest, 9-best.

Table 27. Effect of sex and age on organoleptic evaluation, 52-family panel earning more than $10,000

Age Group	(N)	Tenderness	Flavor	Appearance	Aroma	Juiciness	Overall acceptability
9 - 19	(385)	5.2 ± .40	5.8 ± .45	5.9 ± .41	5.4 ± .38	6.3 ± .41	5.4 ± .49
20 - 29	(87)	5.4 ± .80	5.5 ± .80	5.8 ± .71	5.2 ± .66	4.8 ± .79	5.2 ± .78
30 - 49	(282)	5.8 ± .47	5.8 ± .49	6.0 ± .43	6.0 ± .42	5.0 ± .47	5.5 ± .52
50 +	(109)	6.0 ± .74	5.6 ± .74	6.2 ± .60	6.0 ± .56	5.0 ± .88	5.2 ± .79
Total							
Male	(421)	5.4 ± .62	5.7 ± .62	6.0 ± .61	5.6 ± .49	5.3 ± .61	5.4 ± .62
Female	(442)	5.8 ± .58	5.8 ± .62	6.0 ± .46	5.8 ± .51	5.3 ± .61	5.2 ± .68